



UNIVERSITI PUTRA MALAYSIA

**EFFECTS OF MICRONUTRIENTS (B, CU , FE, MN, MO, ZN)
ON PLANT PERFORMANCE AND YIELD OF PINEAPPLE CVS
MAURITIUS AND MASMERAH PLANTED ON MALAYSIAN
VIRGIN PEAT SOILS**

RAMLAH MOHAMAD

FP 1982 1

EFFECTS OF MICRONUTRIENTS (B, Cu, Fe, Mn, Mo, Zn)
ON PLANT PERFORMANCE AND YIELD OF PINEAPPLE CVS
MAURITIUS AND MASMERAH PLANTED ON MALAYSIAN
VIRGIN PEAT SOILS

by

Ramlah Mohamad

A Thesis submitted in partial fulfilment of
the requirement for the degree of
Master of Agricultural Science in the
Universiti Pertanian Malaysia

1982




This thesis attached hereto, entitled "Effects of Micronutrients (B, Cu, Fe, Mn, Mo, Zn) On Plant Performance and Yield Of Pineapple CVM Mauritius and Masmerah Planted On Malaysian Virgin Peat Soils" prepared and submitted by Ramlah bte Mohamad in partial fulfilment of the requirements for the degree of Master of Agricultural Science (Soil Fertility) is hereby accepted.



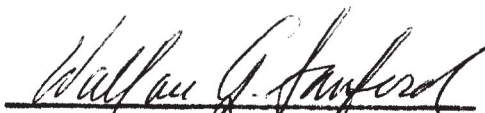
(Dr. Wan Sulaiman Wan Harun)
Chairman.



(Dr. Mohammad Md. Ali)
Internal Examiner.



(Dr. Alias Husin)
Internal Examiner.



(Prof. Wallace G. Sanford)
External Examiner.

Date: 10/2/83

ACKNOWLEDGEMENTS

My sincere gratitude and thanks to my supervisor, Associate Professor Dr. Mohammad Md. Ali and my co-supervisor, Dr. Alias Husin, for their guidance, constructive criticisms and invaluable suggestions.

I am also grateful to the Director-General of Malaysian Agriculture Research and Development Institute for permitting me to pursue my studies as part-time student at Universiti Pertanian Malaysia, Serdang, Selangor. My sincere thanks also go to Puan Salbiah Hussin, Cawangan Statistik, MARDI, for her guidance and advice in Statistics and Field Designs. I will always remember the diligent and conscientious efforts of Encik Malik Ali, Encik Samsuri Saaban and Encik Malik Hussin in carrying out the field work.

My special thanks also go to Miss Tan T.K. for typing the manuscript.

I am also grateful to the following who have helped me in one way or another to complete my studies : Dr. Shariff Ahmad, Dr. Lee C.S., Dr. Tay T.H. and Kakitangan, Cawangan Perkhidmatan Awam.

TABLE OF CONTENTS

	<u>Page</u>
TITLE PAGE	i
APPROVAL SHEET	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	ix
LIST OF FIGURES AND ILLUSTRATIONS	xiv
RINGKASAN	xiv
ABSTRACT	xviii
INTRODUCTION	1
LITERATURE REVIEW	3
2.1. The Pineapple, <u>Ananas comosus</u> (L.) Merr.	3
2.1.1. Cultivar <u>Mauritius</u>	3
2.1.2. Cultivar <u>Masmerah</u>	4
2.2. Malaysian Peat	4
2.2.1. Distribution	4
2.2.2. Morphological characteristics	5
2.2.3. Chemical characteristics	6
2.2.4. Crops grown on peat soils	6
2.3. Functions and Deficiency Symptoms of Micronutrients in Plants	7
2.3.1. Boron	8
2.3.2. Copper	9
2.3.2. Manganese	11
2.3.4. Molybdenum	13
2.3.5. Iron	15
2.3.6. Zinc	16

	<u>Page</u>
MATERIALS AND METHODS	18
3.1. Pot Experiment	18
3.1.1. Soils	18
3.1.2. Experimental design	18
3.1.3. Planting materials	19
3.1.4. Fertiliser application	19
3.1.5. Flower induction	23
3.1.6. Growth measurements	23
3.1.7. Fruit weight	24
3.2. Field Experiment I.	24
3.2.1. Soils	24
3.2.2. Treatments and field layout	24
3.2.3. Planting and weeding	25
3.2.4. Growth measurements	26
3.2.5. Flower induction	27
3.2.6. Fruit weight	27
3.3. Field Experiment II	28
3.3.1. Soils	28
3.3.2. Treatments and field layout	28
3.3.3. Planting	30
3.3.4. Determination of growth measurements, flower induction and fruit weight	30
3.3.5. Sampling and preparation of D-leaf	30
3.4. Field Experiment III	31
3.4.1. Soils	31
3.4.2. Treatments and field layout	31
3.4.3. Planting and weeding	33
3.4.4. Determination of growth measurements, flower induction and fruit weight	33
3.4.5. Sampling and preparation of D-leaf	33

	<u>Page</u>
RESULTS	34
4.1. Deficiency Symptoms of Micronutrients (B, Cu, Fe, Mn, Mo, Zn) in Pineapple cvs <u>Mauritius</u> and <u>Masmerah</u> Planted on Virgin Peat Soils	34
4.2. Pot Experiment	40
4.2.1. Cultivar <u>Mauritius</u>	40
4.2.1.1. Plant height	40
4.2.1.2. Leaf number	41
4.2.1.3. Fruit weight	43
4.2.2. Cultivar <u>Masmerah</u>	43
4.2.2.1. Plant height	43
4.2.2.2. Leaf number	44
4.2.2.3. Fruit weight	47
4.3. Field Experiment I	47
4.3.1. Cultivar <u>Mauritius</u>	47
4.3.1.1. Plant height	47
4.3.1.2. Leaf number	50
4.3.1.3. Fruit weight	50
4.4. Field Experiment II	50
4.4.1. Cultivar <u>Mauritius</u>	50
4.4.1.1. Plant height	50
4.4.1.2. Leaf number	51
4.4.1.3. Fresh and dry weights of D-leaf	53
4.4.1.4. Cu and Zn content of D-leaf	55
4.4.1.5. Fruit weight	60
4.4.2. Cultivar <u>Masmerah</u>	62
4.4.2.1. Plant height	62
4.4.2.2. Leaf number	63
4.4.2.3. Fresh and dry weights of D-leaf	68
4.4.2.4. Cu and Zn content of D-leaf	74
4.4.2.5. Fruit weight	76

4.5.	Field Experiment III	76
4.5.1.	Cultivar <u>Mauritius</u>	76
4.5.1.1.	Plant height	76
4.5.1.2.	Leaf number	77
4.5.1.3.	Fresh and dry weights of D-leaf	77
4.5.1.4.	Fruit weight	80
4.5.2.	Cultivar <u>Masmerah</u>	83
4.5.2.1.	Plant height	83
4.5.2.2.	Leaf number	83
4.5.2.3.	Fresh and dry weights of D-leaf	83
4.5.2.4.	Fruit weight	84
	DISCUSSION	88
5.1.	Deficiency Symptoms of Micronutrients (B, Cu, Fe, Mn, Mo, Zn) on Pineapple cvs <u>Mauritius</u> and <u>Masmerah</u>	88
5.2.	Effects of Micronutrients (B, Cu, Fe, Mn, Mo, Zn) on Plant Height, Leaf Number, Fresh and Dry Weights of D-leaf, Cu and Zn-content of D-leaf and Fruit Weight of cv <u>Mauritius</u>	90
5.2.1.	Plant height	90
5.2.2.	Leaf number	94
5.2.3.	Fresh and dry-weights of D-leaf	95
5.2.4.	Cu and Zn-content of D-leaf	96
5.2.5.	Fruit weight	98
5.3.	Effects of Micronutrients (B, Cu, Fe, Mn, Mo, Zn) on Plant Height, Leaf Number, Fresh and Dry Weights of D-leaf, Cu and Zn-content of D-leaf and Fruit Weight of cv <u>Masmerah</u>	102
5.3.1.	Plant height	102
5.3.2.	Leaf number	105
5.3.3.	Fresh and dry-weights of D-leaf	105
5.3.4.	Cu and Zn-content of D-leaf	106
5.3.5.	Fruit weight	106

	<u>Page</u>
SUMMARY AND CONCLUSIONS	108
LITERATURE CITED	111
APPENDIX	

LIST OF TABLES

<u>TABLE</u>		<u>Page</u>
1.	Rates of fertiliser used in the experiment	22
2.	Proportions of fertilisers applied	22
3.	Levels of micronutrients used in the experiment	25
4.	Levels of P, Cu, and Zn used in the experiment	28
5.	Levels of Cu and Zn used in the experiment	31
6.	Analysis of variance on the main and two-factor interaction effects of B, Cu, Fe, Mn, Mo, Zn on monthly plant height of cv <u>Mauritius</u> (pot experiment)	120
7.	Main and interaction effects of B, Cu, Fe, Mn, Mo, Zn on mean plant height of cv <u>Mauritius</u> (pot experiment)	121
8.	Analysis of variance of the main and two-factor interaction effects of B, Cu, Fe, Mn, Mo, Zn on monthly mean leaf number per plant of cv <u>Mauritius</u> (pot experiment)	124
9.	Main and interaction effects of B, Cu, Fe, Mn, Mo, Zn on mean leaf number per plant of cv <u>Mauritius</u> (pot experiment)	125
10.	Analysis of variance of the main and two-factor interaction effects of B, Cu, Fe, Mn, Mo, Zn on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Mauritius</u> (pot experiment)	128
11.	Main and interaction effects of B, Cu, Fe, Mn, Mo, Zn on mean fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Mauritius</u> (pot experiment)	129
12.	Analysis of variance on main and two-factor interaction effects of B, Cu, Fe, Mn, Mo, Zn on monthly plant height of cv <u>Masmerah</u> (pot experiment)	132
13.	Main and interaction effects of B, Cu, Fe, Mn, Mo, Zn on mean plant height of cv <u>Masmerah</u> (pot experiment)	133
14.	Analysis of variance on main and two-factor interaction effects of B, Cu, Fe, Mn, Mo, Zn on mean leaf number per plant of cv <u>Masmerah</u> (pot experiment)	136
15.	Main and interaction effects of B, Cu, Fe, Mn, Mo, Zn on mean leaf number per plant of cv <u>Masmerah</u> (pot experiment)	137
16.	Analysis of variance on main and two-factor interaction effects of B, Cu, Fe, Mn, Mo, Zn on mean fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Masmerah</u> (pot experiment)	140

<u>TABLE</u>	<u>Page</u>
17. Main and interaction effects of B, Cu, Fe, Mn, Mo, Zn on mean fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Masmerah</u> (pot experiment)	141
18. Analysis of variance for plant height of cv <u>Mauritius</u> from the fourth to ninth month of planting, when treated with different levels of B, Cu, Fe, Mn, Mo, Zn	144
19. Effects of B, Cu, Fe, Mn, Mo, Zn on plant height of cv <u>Mauritius</u> (field experiment I)	145
20. Duncan's Multiple Range Test on the effect of micronutrients on plant height of cv <u>Mauritius</u> from the seventh to ninth month of planting	146
21. Analysis of variance for mean number of leaves per plant of cv <u>Mauritius</u> from the fourth to the ninth month of planting, when treated with different levels of B, Cu, Fe, Mn, Mo, Zn	147
22. Effects of B, Cu, Fe, Mn, Mo, Zn on leaf number of cv <u>Mauritius</u> (field experiment I)	148
23. Analysis of variance for fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Mauritius</u> , when treated with different levels of B, Cu, Fe, Mn, Mo, Zn	149
24. Effects of B, Cu, Fe, Mn, Mo, Zn on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Mauritius</u> (field experiment I)	150
25. Duncan's Multiple Range Test on the effect of micronutrients on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Mauritius</u>	151
26. Analysis of variance of the effect of broadcasting P, Cu, Zn and their interactions on monthly plant height of cv <u>Mauritius</u>	152
27. Effects of broadcasting P, Cu, Zn and their interactions on plant height of cv <u>Mauritius</u> (field experiment II)	153
28. Analysis of variance of the effect of broadcasting P, Cu, Zn and their interactions on monthly mean number of leaves per plant of cv <u>Mauritius</u>	155

<u>TABLE</u>	<u>Page</u>
29. Effect of broadcasting P, Cu, Zn and their interactions on leaf number of cv <u>Mauritius</u> (field experiment II)	156
30. Analysis of variance of monthly mean fresh and dry weights of D-leaf of cv <u>Mauritius</u> when broadcasted with P, Cu and Zn at different levels	158
31. Mean values of monthly fresh and dry weights of D-leaf of cv <u>Mauritius</u> , when broadcasted with Cu and Zn at different levels	160
32. Analysis of variance of monthly Cu and Zn-content of D-leaf when broadcasted with P, Cu and Zn at different levels on pineapple cv <u>Mauritius</u>	161
33. Mean values of Cu and Zn-content of the D-leaf when broadcasted with Cu and Zn at different levels on pineapple cv <u>Mauritius</u>	163
34. Analysis of variance on the effect of broadcasting P, Cu, Zn and their interactions on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Mauritius</u>	164
35. Effect of broadcasting P, Cu, Zn and their interactions on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Mauritius</u>	165
36. Analysis of variance on the effect of broadcasting P, Cu, Zn and their interactions on monthly plant height of cv <u>Masmerah</u>	167
37. Effects of broadcasting P, Cu, Zn and their interactions on plant height of cv <u>Masmerah</u>	168
38. Analysis of variance on the effect of broadcasting P, Cu, Zn and their interactions on monthly mean leaf number per plant of cv <u>Masmerah</u>	170
39. Effect of broadcasting P, Cu, Zn and their interactions on leaf number of cv <u>Masmerah</u>	171
40. Analysis of variance of monthly fresh and dry weights of D-leaf of cv <u>Masmerah</u> when broadcasted with P, Cu and Zn at different levels	173

<u>TABLE</u>	<u>Page</u>
41. Mean values of monthly fresh and dry weights of D-leaf of cv <u>Masmerah</u> when broadcasted with Cu and Zn at different levels	175
42. Analysis of variance of monthly Cu and Zn-content of D-leaf when broadcasted with P, Cu, Zn at different levels on pineapple cv <u>Masmerah</u>	176
43. Mean values of monthly Cu and Zn content of the D-leaf when broadcasted with Cu and Zn at different levels on pineapple cv <u>Masmerah</u>	178
44. Analysis of variance on the effect of broadcasting P, Cu, Zn and their interactions on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Masmerah</u>	179
45. Effect of broadcasting P, Cu, Zn and their interactions on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Masmerah</u>	180
46. Analysis of variance on foliar treated Cu and Zn and their interactions on the monthly plant height of cv <u>Mauritius</u>	182
47. Effects of foliar treated Cu and Zn and their interactions on plant height of cv <u>Mauritius</u>	183
48. Analysis of variance on foliar treated Cu and Zn and their interactions on the monthly mean normal of leaves per plant of cv <u>Mauritius</u>	184
49. Effect of foliar treated Cu and Zn and their interactions on leaf number of cv <u>Mauritius</u>	185
50. Analysis of variance of monthly fresh and dry weights of D-leaf when foliar treated with Cu and Zn at different levels (cv <u>Mauritius</u>)	186
51. Mean values of monthly fresh and dry weights of D-leaf when foliar treated with Cu and Zn at different levels (cv <u>Mauritius</u>)	188
52. Analysis of variance on the effect of foliar treated Cu and Zn and their interactions on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Mauritius</u>	189

<u>TABLE</u>	<u>Page</u>
53. Effects of foliar-treated Cu and Zn and their interactions on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Mauritius</u>	190
54. Analysis of variance on the effect of foliar-treated Cu, Zn and their interactions on monthly plant height of cv <u>Masmerah</u>	191
55. Effects of foliar-treated Cu and Zn and their interactions on plant height of cv <u>Masmerah</u>	192
56. Analysis of variance on the effects of foliar-treated Cu, Zn and their interactions on monthly mean leaf number per plant of cv <u>Masmerah</u>	193
57. Effects of foliar-treated Cu and Zn and their interactions on leaf number of cv <u>Masmerah</u>	194
58. Analysis of variance of monthly fresh and dry weights of D-leaf when foliar-treated with Cu and Zn at different levels (cv <u>Masmerah</u>)	195
59. Mean values of monthly fresh and dry weights of D-leaf when foliar-treated with Cu and Zn at different levels (cv <u>Masmerah</u>)	197
60. Analysis of variance on the effect of foliar-treated Cu and Zn and their interactions on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Masmerah</u>	198
61. Mean values of foliar-treated Cu and Zn and their interactions on fruit weight, fruit length and diameter, core length and diameter, fruit sugar and acid content of cv <u>Masmerah</u>	199

LIST OF FIGURES AND ILLUSTRATIONS

<u>FIGURE</u>		<u>Page</u>
1.	Effect of B and Cu, applied at different levels, on the monthly plant height of pineapple cv <u>Mauritius</u> (pot experiment)	42
2.	B x Zn and Cu x Zn interaction effects on the plant height of pineapple cv <u>Masmerah</u> (pot experiment)	45
3.	Effect of different levels of Cu on monthly plant height of pineapple cv <u>Mauritius</u> (field experiment I)	49
4.	Effect of Cu and Zn on monthly plant height of cv <u>Mauritius</u> (field experiment II)	52
5.	Effect of P and P x Zn interaction on the monthly leaf number of pineapple cv <u>Mauritius</u> (field experiment II)	54
6.	Fresh and dry weights of D-leaf of cv <u>Mauritius</u> when broadcasted with Cu and Zn at 0, 5, 10 kg/ha	56
7.	Cu and Zn-content of D-leaf of cv <u>Mauritius</u> when broadcasted with Cu and Zn at 0, 5, 10 kg/ha	59
8.	Effect of different levels of Zn and Cu x Zn on fruit weight of cv <u>Mauritius</u>	61
9.	Effect of P, Cu, Zn, Cu x Zn and P x Cu x Zn on plant height of pineapple cv <u>Masmerah</u>	64
10.	P x Zn and P x Cu x Zn interaction effects on the leaf number of pineapple cv <u>Masmerah</u> on the fourth, seventh and eighth months of planting	69
11.	Monthly fresh and dry weights of D-leaf when broadcasted with Cu and Zn at 0, 5, 10 kg/ha on pineapple cv <u>Masmerah</u>	72
12.	Cu and Zn-content of the D-leaf when broadcasted with Cu and Zn at 0, 5, 10 kg/ha (cv <u>Masmerah</u>)	75
13.	Effect of foliar-treated Cu and Zn at different levels on monthly plant height of cv <u>Mauritius</u>	78
14.	Fresh and dry weights of D-leaf of cv <u>Mauritius</u> when foliar-treated with Cu and Zn at 0, 5, 10 kg/ha	81
15.	Monthly fresh and dry weights of D-leaf when foliar-treated with Cu and Zn at 0, 5, 10 kg/ha (cv <u>Masmerah</u>)	86

PLATESPage

1a.	Normal pineapple plant of cv <u>Mauritius</u> with white powdery layer of trichomes both on the upper and lower sides of the leaves	35
1b.	Copper deficient pineapple plant sharing unusual dark green colour of the leaves of cv <u>Mauritius</u>	36
2.	Copper deficient plant with 'die-back' symptoms of the young leaves of cv <u>Mauritius</u>	37
3.	"Witches broom" effect of copper deficient plant of cv <u>Mauritius</u>	37
4.	Severe copper-deficient plant of cv <u>Mauritius</u>	38
5.	Sporadic nature of copper deficient plants of cv <u>Mauritius</u> in the field	38
6.	A non-treated copper plot of cv <u>Masmerah</u> with healthy plants	39

DIAGRAMS

1.	2^7 Factorial experiment V B Cu Zn Mn Fe Mo	20
2.	Field layout for broadcasted P x Cu x Zn experiment	29
3.	Field layout for foliar-treated Cu x Zn experiments	32

RINGKASAN

Tujuan utama kajian ini ialah untuk mengenalpasti kepentingan zat makanan mikro B, Fe, Mn, Mo dan terutama sekali Cu and Zn, bagi tanaman nenas kultivar Mauritius dan Masmerah di atas tanah gambut dara di Semenanjung Malaysia. Satu percubaan pasu dan tiga percubaan ladang telah dijalankan untuk menentukan kesan-kesan makanan mikro ke atas ciri-ciri seperti ketinggian pokok, bilangan daun, berat basah dan kering daun 'D', kandungan zat makanan Cu dan Zn di dalam daun 'D', dan berat buah. Tanda-tanda kekurangan zat makanan itu juga dititik beratkan. Kajian ke atas arahan zat-P ke atas kekurangan zat Cu dan Zn juga telah dijalankan.

Hanya zat Cu sahaja telah menunjukkan tanda-tanda kekurangan yang nyata pada pokok nenas kultivar Mauritius, manakala zat B, Fe, Mn, Mo dan Zn tidak kelihatan memberi tanda kekurangan yang jelas. Bagi kultivar Masmerah pula ke enam zat makanan mikro yang dikaji tidak menunjukkan tanda kekurangan yang nyata.

Zat Cu juga telah memberi kesan yang bererti ke atas ketinggian pokok, berat basah dan kering daun 'D', juga kandungan zat Cu dalam daun 'D' pada kultivar Mauritius. Walubagaimana pun, kesan ke atas bilangan daun dan berat buah adalah tidak bererti. Berlakunya tanda-tanda kekurangan zat Cu pada pokok yang ditanam di ladang adalah berkelompok-kelompok (sporadic). Kekurangan ini mula kelihatan pada bulan yang keempat atau kelima selepas ditanam. Oleh kerana tidak ada perbezaan yang bererti kelihatan ke atas ciri-ciri pokok yang dikaji apabila berlainan kadar Cu diberi (5, 10, 15 kg Cu/ha), dengan itu kadar 5 kg Cu/ha adalah mencukupi untuk

mengatasi tanda-tanda kekurangan yang terdapat di ladang. Kesan zat Zn ke atas tanaman kultivar Mauritius didapati tidak memberi kesan yang bererti.

Bagi kultivar Masmerah pula, zat makanan mikro khasnya Cu dan Zn tidak memberi kesan yang bererti dari segi ketinggian pokok, bilangan daun, berat basah dan kering daun 'D', kandungan zat Cu dan Zn dalam daun 'D' dan juga berat buah.

Dari kajian yang telah dijalankan, didapati tidak ada aruhan zat P ke atas kekurangan Cu dan Zn berlaku bagi kedua-dua kultivar. Dengan itu, kesimpulan yang boleh diperolehi daripada penyelidikan yang telah dijalankan ialah bahawa hanya zat Cu sahaja memainkan peranan yang penting untuk tanaman nenas kultivar Mauritius di - tanah gambut dara di Semenanjung Malaysia.

ABSTRACT

The objective of this study is to establish the importance of micronutrients B, Fe, Mn, Mo and especially Cu and Zn for the cultivation of pineapple cvs Mauritius and Masmerah on virgin peat soils in Peninsular Malaysia. A pot and three field trials were set up to determine the effects of these micronutrients on the plant height, leaf number, fresh and dry weights of D-leaf, Cu and Zn content of D-leaf and the fruit weight of these two cultivars. The deficiency symptoms were also observed. A study on R-induced Cu and Zn deficiencies was also carried out on the two cultivars.

Only Cu showed distinct deficiency symptoms in both the pot and field trials in pineapple cv Mauritius while none was observed for B, Fe, Mn, Mo, and Zn. No distinct deficiency symptoms of B, Cu, Fe, Mn, Mo and Zn were observed on pineapple cv Masmerah.

Only Cu was observed to give significant effect to the plant height, fresh and dry weight of D-leaf and Cu-content of D-leaf on cv Mauritius. However, the leaf number and fruit weight were not significantly affected. The Cu-deficient plants in the field were observed to be sporadic or pocket-like in distribution. The deficiency was observed to occur as early as the fourth or fifth month of planting. No significant difference was observed with the different levels of Cu (5, 10, 15 kg/ha) applied on the above-mentioned factors investigated. Thus, Cu at 5 kg/ha would be sufficient to overcome the deficiency symptoms in the field. The effect of Zn was observed to be non-significant for the cultivation of pineapple cv Mauritius.

There was no significant effect of the micronutrients, especially for Cu and Zn on the plant height, leaf number, fresh and dry weights of D-leaf, Cu and Zn-content of D-leaf and fruit yield of cv Masmerah. There was no P-induced Cu and Zn deficiencies occurring in the field with these two cultivars.

Thus, only Cu was shown to be essential for the cultivation of pineapple cv Mauritius on virgin peat soils of Peninsular Malaysia.

1. INTRODUCTION

In Malaysia, pineapple (Ananas comosus (L) Merr.) is mainly grown on peat soils. It is an economically viable crop because it can tolerate low soil acidity, which is characteristic of Malaysian peat (pH 3.5-3.8) and it is also relatively resistant to pests and diseases as compared to other annual crops which are also commonly cultivated on peat.

Peat soils have been considered to be poor in nutrient contents but due to its outstanding advantage of possessing high nutrient holding potential or cation exchange capacity, it has been extensively cultivated with annual crops.

Micronutrient deficiencies in peat soils have been reported widely both abroad and locally. Davis and Lucas (1959) reported Mn, B, Cu, Fe, Zn and Mo deficiencies for plants grown on peat soils. Report on Cu deficiency on peat and muck soils had been made by Caldwell (1966) while William (1971) reported Mo deficiency on a wide range of acid soils. Batey (1971) stated that Mo and B deficiencies occur most commonly on peaty soils or mineral soils with a high organic matter content. Andriesse (1974) reported Cu, Fe, Mn and often Zn deficiencies on peat soils in West Kalimantan.

Locally, Tay (1969) reported micronutrient deficiencies especially for Fe, Cu and Zn on pineapple grown on peat soils. Observations have been recorded on B deficiency on tomato (Joseph, Hussein and William, 1970) and oil palm (Kanapathy, Tan and Cheah, 1974; 1975); Cu deficiency on maize and cassava (Kanapathy, 1972; 1976);

Cu, Zn and Mn deficiencies on oil palm (Ng and Tan, 1974) and Cu and other micronutrients on groundnuts and sorghum (Chew, Joseph and Ramli, 1979).

Though probable symptoms of Cu and Zn deficiencies on pineapple have been reported earlier (Tay, 1969), to-date no detailed studies have been carried out on the effect of these micronutrients on plant performance, and fruit yield of pineapple when planted on virgin peat soils.

The objectives of this study are as follows:

- 1) To observe the importance of micronutrients B, Cu, Fe, Mn, Mo, Zn (main and two-factor interaction effects) for pineapple cultivation on virgin peat soils.
- 2) To identify the important micronutrient requirement for pineapple cvs Mauritius, which is mainly for fresh fruit production, and Masmerah, a canning cultivar.
- 3) To determine the optimum level of application of Cu and Zn (the two commonly deficient micronutrients for pineapple grown on Malaysian peat soils) for pineapple cvs Mauritius and Masmerah.
- 4) To observe the difference in the response of plant performance, and fruit yield to either broadcast or foliar treated Cu and Zn in pineapple cvs Mauritius and Masmerah.
- 5) To study the effect of P-induced Cu and Zn deficiency in pineapple cvs Mauritius and Masmerah.

2. LITERATURE REVIEW

2.1. The Pineapple, *Ananas comosus* (L.) Merr.

Pineapple is a terrestrial herb, native of South America, and is a member of Bromeliaceae. Its characteristic features are short stem with rosette of long, narrow leaves, either with or without spines. The inflorescence is terminal coalescing into fruit which is a syncarpous and with the main axis growing beyond to form a tuft or crown of leaves. Pineapple fruits with seeds are rarely in existence nowadays, and this is due to selection made for seedlessness through mutation.

Its other related species include *Ananas bracteatus* (Lindl.) Schultes, *A. erectifolius* L.B. Smith and *A. ananassoides* (Bak.) Smith, which are found wild and distributed throughout the tropics.

2.1.1. Cultivar *Mauritius*

This cultivar is grown extensively for fresh fruit pineapple. It is classified under the Queen Group and the plant is the smallest of the Malaysian cultivars (Wee, 1972). The leaves are dark green in colour with broad, central red stripe, and the edges are lined with red spines. The fruit is small (1.0 kg) with prominent and bulging eyes. The flesh is yellow in colour with high sugar content (15^oB - 19^oB) and high citric acid content (0.6% - 0.8%).

Ground and aerial suckers are very common with this cultivar and they are generally used as planting materials. Slips are absent.

2.1.2. Cultivar Masmerah

This cultivar is a canning cultivar and is selected from the Singapore Spanish population. It has more vigorous growth than the Singapore Spanish. The leaves are erect and spineless. The fruits are bigger in size (1.4 kg), cylindrical in shape with flesh of golden colour and translucent. Fruit-lets are flat and broad.

Slips are produced just below the fruit arising from the peduncle, and they are commonly used as planting materials. The sugar content is very low (10°B - 12°B) with low acid content (0.3% - 0.5%).

2.2. Malaysian Peat

2.2.1. Distribution

Peat soils occur widely in Malaysia. In West Malaysia, 6% of the land area or approximately 800,000 hectares are peat soils. These occur mainly in the States of Perak, Selangor and Western Johore on the west coast, and Kelantan, Trengganu and Eastern Johore on the east coast. In Sarawak the area under peat is about 1.4 million hectares or 13% of the land area.

Peat soils of West Malaysia are made up of semi-decomposed woody materials. The condition that leads to their

formation is mainly due to the permanent water-logging in basin-shaped depression. Generally, they are found along the poorly drained coastal areas or as small, localized patches in the inland areas. They vary in depth from 3 meters to more than 10 meters.

Coulter (1957) classified Malaysian peat under the group 'oligotrophic'. This group includes moss peats and woody peats, low in mineral content, especially Ca and are acid in reaction due to the low base content of the in-flowing water.

2.2.2. Morphological characteristics

The forest peats of West Malaysia are usually blackish-brown or reddish-brown in colour. They consist of woody materials in different stages of decomposition. The size of the woody materials increases with depth. They have good texture and permeability as they are mainly made up of organic matter (89% organic matter). The water holding capacity is very high and equals 15 to 30 times its own dry weight (Tay, 1969). When undrained, peat soils are always water-logged and the water-table can be as high as the soil surface. Consequently, aeration is poor. Thus, before peat soils can be used for cultivation, drainage is very essential. However, with excessive drainage, peat soils can undergo 'irreversible drainage' (Coulter, 1950; 1957). This will lead to considerable consolidation and oxidation of the peat soils (Coulter, 1957).